PHACELIA TANACETIFOLIA FLOWER STRIPS AS A COMPONENT OF INTEGRATED FARMING

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ABSTRACT

The impact of a *Phacelia tanacetifolia* field margin on aphid-specific predators in winter wheat was investigated at one of the MAFF/LINK Integrated Farming Systems (IFS) sites. Syrphidae were attracted to the *Phacelia* strip and gut dissections confirmed they were feeding on the pollen before distributing up to 100m into the field. No evidence of improved fecundity as a result of feeding on *Phacelia* was found. Ichneumonidea were also more abundant in the *Phacelia* strip compared to the adjacent wheat crop. There were trends towards higher numbers of Braconidae, Proctotrupoidea and *Platypalpus* spp. in the IFS plots whereas Chalcidoidea were more numerous in the conventional farming system plots. Aphid abundance and percentage parasitism were unaffected by differences in aphid-specific predator distribution.

INTRODUCTION

An option for arable crop production currently being investigated throughout Europe is the adoption of integrated farming methods (Holland *et al*., 1994). One of the main objectives of integrated farming is to utilise natural regulatory mechanisms and thereby reduce the need for inputs of pesticides, fertilizers and fuels (Anon, 1993). The establishment of a flower border strip which is attractive to cereal aphid predators, for example hoverflies (Diptera:Syrphidae), is one technique which may enhance cereal aphid control and so reduce the need for aphicides. Adult hoverflies require proteins from pollen to mature their reproductive systems (Schreiber, 1948). Eggs are then laid in association with aphid colonies on which the larvae subsequently feed (Dean, 1974). Many hymenopteran parasitoids also feed on non-host flowers to obtain nectar or pollen (Jervis *et al*., 1993) which can increase fecundity and longevity (Jervis and Kidd, 1986). A number of plant species have been evaluated for their attractiveness to hoverflies (MacLeod, 1992) and hymenopteran parasitoids (Jervis *et al*., 1993). In addition *Phacelia tanacetifolia* pollen is very distinctive and can be readily identified within the guts of dissected hoverfly specimens so aiding experimental evaluations (Hickman, 1994).

A new programme of research was started in 1992 to investigate integrated farming - the MAFF/LINK Integrated Farming Systems project (Holland, 1994). As part of a programme of measures to reduce the inputs of agrochemicals, strips of *Phacelia* were established around the edge of cereal fields at some of the experimental sites. Their impact on hoverfly, parasitoid and aphid populations was evaluated at one of these sites.

MATERIALS AND METHODS

At the MAFF/LINK IFS site in north Hampshire, conventional farm practice (CFP) and integrated farming system (IFS) were compared using adjacent pairs of plots (min. size 5 ha, min. width 100 m). Detailed descriptions of the experimental design are available in Holland

(1994). In this study four pairs of winter wheat plots were used. A strip of *Phacelia* was sown in mid April along the longest edge (300-400 m) of the four winter wheat IFS plots. A transect of fluorescent yellow water traps (19 cm diameter) were located at crop height in a line at 45° and distances of 10, 25, 50 ,75 and 100 m from each *Phacelia* strip. Another transect of traps was also located on the opposite side of the field but adjacent to the conventional plot. An additional trap was placed within each *Phacelia* strip and on one edge of each conventional plot. The traps were emptied weekly from the 13th June 1993 until the 16th July 1993. *Phacelia* started to flower on the 21st June 1993. The contents of each trap were stored separately in 70% alcohol until identification. The following groups only are discussed: Syrphidae, *Aphidius* spp. (Braconidae), other Braconidae, Ichneumonidea, Proctotrupoidea, Chalcidoidea. Cynipoidea, *Platypalpus* spp. (Diptera:Empididae). Total numbers caught in each group were analyzed separately using Analysis of Variance (ANOVA) with farming system and distance from field margin as factors.

The proportion of Syrphidae which had been feeding on the *Phacelia* was determined by dissecting each syrphid and recording the presence/absence of *Phacelia* pollen. To obtain an estimate of fertility the presence/absence of eggs was also noted. The proportion of males and females with pollen and proportion of females with eggs (arc sine transformed) were analyzed separately using ANOVA with farming system and distance as factors. Means were separated using LSD tests.

Two winter wheat IFS plots were sampled using a Diettrich vacuum insect sampler (D-vac). Five samples were taken (10 s suction, repeated five times at 2 m intervals) from the *Phacelia* strip, at 3 m from the crop edge (in the selectively sprayed Conservation Headland area) and at 10 m from the crop edge. Samples were frozen and the above groups identified. To determine differences between sampling positions individual groups were analyzed using one-way ANOVA.

To estimate the proportion of parasitised aphids, 10 ears of aphid infested wheat were collected in the vicinity of each water trap on three separate occasions. Ten grain aphids per ear were removed and reared on wheat leaves in glass vials in the laboratory until each aphid had reached adulthood and begun to produce offspring. Emergent parasitoids and hyperparasitoids were identified.

Aphid numbers, species and life-stage (adult or nymph) was assessed on 50 tillers in each winter wheat plot on five occasions. To determine whether species composition differed between the two farming systems the ratio of the two species was calculated. To determine whether the population age structure varied between the two farming systems the ratio of adults to nymphs was calculated.

RESULTS

The ANOVA of the water trap data revealed that there were significantly ($P<0.05$) more *Platypalpus* spp. in the IFS plots and numbers in the *Phacelia* strip and conventional field margin were significantly ($P<0.05$) less compared to the crop (Table 1). The numbers of Proctotrupoidea and Ichneumonidea were significantly ($P<0.05$) greater at the field margin, but only significantly higher in the *Phacelia* strip with the latter. There were trends towards higher numbers of Syrphidae in the *Phacelia* strip and more Proctotrupoidea and other Braconidae in the IFS plots, and greater numbers of Chalcidoidea in the CFP plots.

TABLE 1. Total number per trap (± pooled SE) of each invertebrate group captured in water traps in each plot and results of ANOVA. (ns=not significant, D=significant differences between sampling distances, S=significant difference between farming systems).

Invertebrate group	CFP	IFS	SE	ANOVA results
Aphidius spp.	16.6	3.4	1.29	ns
Other Braconidae	59.4	77.7	10.3	ns
Ichneumonidea	12.7	14.8	1.3	ns
Proctotrupoidea	81.9	94.4	10.7	D
Chalcidoidea	346.2	295.6	43.5	ns
Cynipoidea	11.9	10.5	1.3	ns
Syrphidae	16.5	20.5	2.2	ns
Platypalpus spp.	251.0	378.3	26.0	S,D

The ANOVA comparing the different D-vac suction sample positions indicated that there were no significant differences (P>0.05). This was expected because of the low between-subjects degrees of freedom (2). There were trends towards higher numbers of *Aphidius* spp., other Braconidae, Proctotrupoidea and Syrphidae in the *Phacelia* strip whilst Cynipoidea and *Platypalpus* spp. were more abundant in the crop (Table 2).

TABLE 2. Mean number (± SE) of each invertebrate group per D-vac sample in *Phacelia* strip, crop margin and at 10m from the crop edge.

Invertebrate group	*Phacelia*		Crop edge	10m into crop
Aphidius spp.	10.6	(±2.4)	5.2 (±0.7)	7.6 (±0.9)
Other Braconidae	186.9	(±80.1)	26.7 (±6.1)	16.5 (±2.2)
Ichneumonidea	1.6	(±0.8)	2.2 (±0.5)	2.6 (±0.3)
Proctotrupoidea	16.2	(±8.5)	4.2 (±1.5)	6.9 (±0.7)
Chalcidoidea	8.0	(±1.0)	3.8 (±0.5)	7.5 (±1.3)
Cynipoidea	1.8	(±0.6)	2.6 (±0.5)	3.0 (±0.7)
Syrphidae	1.9	(±0.6)	0.6 (±0.3)	0.4 (±0.2)
Platypalpus spp.	3.0	(±0.9)	6.3 (±1.6)	8.9 (±1.1)

The ANOVA comparing the proportion of Syrphidae containing *Phacelia* pollen indicated that significantly (P<0.001) more males and females had fed on *Phacelia* in the IFS plots, but this only varied significantly (P<0.01) with distance from the field margin for females. The Syrphidae were distributing throughout the IFS plot and occasionally further into the CFP plots (Table 3).

TABLE 3. Percentage of Syrphidae males and females containing *Phacelia* pollen, and the proportion of females with eggs in each farming system.

Distance from field margin	Males CFP	Males IFS	Females CFP	Females IFS	Eggs CFP	Eggs IFS
0m	3	43	8	66	24	35
10m	6	33	4	22	48	24
25m	4	34	6	22	19	34
50m	5	15	0	31	13	36
75m	6	18	13	0	28	65
100m	0	24	6	13	35	30
Pooled S.E	8		7		10	

No significant (P>0.05) effects were found for the distribution of Syrphidae containing eggs. Results were variable with peaks at 10m in the CFP plots and at 75m in the IFS plots (Table 3).

TABLE 4. Mean number of each aphid species, the species ratio and adult/nymph ratio per tiller in each farming system.

Farming system	Sampling date 8/6/93	17/6/93	23/6/93	29/6/93	7/7/93
	Mean number of grain aphids (GA)				
CFP	0.3	1.1	0.5	0.9	1.2
IFS	0.6	1.7	0.9	1.1	0.7
	Mean number of rose-grain aphids (RGA)				
CFP	0.1	0.3	0.2	0.3	0.4
IFS	0.1	0.3	0.2	0.4	0.7
	Ratio of GA:RGA				
CFP	0.5	0.9	0.6	0.4	0.3
IFS	0.4	0.2	0.3	0.6	1.4
	Ratio of GA adults:nymphs				
CFP	1.7	3.0	4.7	3.1	6.9
IFS	1.9	4.6	5.7	1.6	4.0
	Ratio of RGA adults:nymphs				
CFP	2.3	4.0	10.4	3.2	2.8
IFS	4.5	1.6	5.2	5.7	2.9

Aphid populations were variable and low in all plots (0-1.7 per tiller) and there appeared to be no consistent difference in the number of species, their ratio or adult to nymph ratio between the CFP and IFS plots (Table 4).

The percentage parasitism was very low in all plots and did not vary with distance from the field margin (Table 5). The higher numbers of parasitoids found in the *Phacelia* strip was not therefore reflected in the proportion of parasitised aphids. *Aphidius* spp. were the most common aphid parasitoids throughout the plots.

TABLE 5. The percentage of parasitised aphids in each farming system at different distances from the field margin.

Distance from field margin	CFP	IFS
0m	5.7	5.7
10m	7.1	10.0
25m	0	1.4
50m	8.6	5.7
75m	4.3	2.9
100m	7.1	7.1
Overall mean	5.47	5.47

DISCUSSION

The results of the D-vac suction samples and water traps although generally not conclusive did indicate some possible trends. Syrphidae were utilizing the pollen source provided by *Phacelia* as found by Harwood *et al.*, (this volume) and were subsequently distributing into the adjacent crop. The abundance of Syrphidae in the crop was, however, not improved by the presence of the *Phacelia* strip. Whether Syrphidae fertility was being improved was not verified because of variable results from gut dissections and the absence of eggs in the crop. *Phacelia* was also acting as an attractant to a range of parasitoids and hyperparasitoids notably *Aphidius* spp., other Braconidae and Proctotrupoidea but again the abundance was not increased in the IFS compared to the CFP plots. This was also reflected in the relatively even abundance of aphids and the proportion parasitised in the IFS and CFP plots. *Phacelia* may only be attracting airborne invertebrates from the adjacent hedgerow, although the water trap samples (insufficient space to present complete data) did not indicate a massive influx of parasitoids when the *Phacelia* started to flower. The impact of providing such a massive pollen source on aphid-specific predator populations requires further investigation to determine whether populations are increasing or redistributing so lowering levels of aphid control in other areas. Incorporating Umbelliferae species into the *Phacelia* may also enhance parasitoid populations as these are visited by a wide range of parasitoids species (Jervis *et al.*, 1993). The greater abundance of *Platypalpus* spp. in the IFS plots was probably a result of another component of the integrated system and require further investigation.

The scale required to investigate different farming systems often limits within-year replication and therefore the likelihood of detecting statistically significant differences. Further investigations over several years are required to confirm the findings from these initial studies. In these investigations the effect of polyphagous aphid predators could not be excluded and therefore more specific experiments are required to isolate the impact of the aphid specific predators reported here.

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EFFECTS OF UNSPRAYED CROP EDGES ON FARMLAND BIRDS

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ABSTRACT

In 1992 and 1993 the abundance of three farmland bird species, *Motacilla flava flava, Alauda arvensis* and *Anthus pratensis* in sprayed and unsprayed edges of winter wheat fields was investigated. Compared with the sprayed crop edges, the number of visits of *Motacilla flava flava* was significantly 3 - 4.5 times higher on the unsprayed edges. There was no difference in the frequency of visits for the other two species. The number of territories of *Motacilla flava flava* per hectare correlates with the percentage area of winter wheat on the farms.

INTRODUCTION

Over the past few decades there has been a substantial decline in the number of farmland birds in the Netherlands (Kwak *et al.*, 1988). This may be due in part to the use of herbicides and insecticides on arable land. In addition to direct effects there may also be indirect effects, for example resulting from changes in food abundance (*cf.* de Snoo & Canters, 1990). It has been demonstrated that leaving the edges of cereal fields unsprayed benefits populations of gamebirds such as *Perdix perdix* (Partridge) and *Phasianus colchicus* (Pheasant), because the greater abundance of insects in the unsprayed crop edges benefits chick survival (Rands, 1985; 1996). In the present study it was investigated whether unsprayed crop edges also attract small songbirds such as *Motacilla flava flava* (Blue-headed wagtail), *Alauda arvensis* (Skylark) and *Anthus pratensis* (Meadow pipit). *Motacilla flava flava* and *Anthus pratensis* are both insectivores, while *Alauda arvensis* is also partly herbivorous eating weed seeds, seedling cotyledons and leaves from weeds and crop (Cramp, 1988; Green, 1978; 1980). The research is part of the Dutch Field Margin Project being undertaken in the Haarlemmermeerpolder. The aim of this project is to develop a management strategy for promoting nature conservation in arable fields and reducing pesticide drift to non-target areas. Effects on weeds, invertebrates, vertebrates, pesticide drift and costs to the farmer are being studied.

METHODS

The research was conducted in the Haarlemmermeerpolder (clay soil) in 1992 and 1993. In this polder most parcels of land are 1000 m long and 200 m wide and are bordered by ditches. The most common rotation on the farms was: winter wheat, followed by potatoes, a second winter wheat crop, and finally sugar beet. The study was carried out on 8 farms in 1992 and on 7 farms in 1993. In one winter wheat field at each farm a 6-metre wide crop edge bordering on a ditch was left unsprayed; these crop edges had a mean length of 424 $\pm$ 116 m. The total length of unsprayed crop edge was 3790 m in 1992 and 2560 m in 1993. No herbicides or insecticides were used on these margins. Spraying with fungicides was allowed, but no organophosphate fungicides were used. The unsprayed edges were compared with sprayed edges which were generally in the same field. On the unsprayed crop edges weed coverage increased substantially, as did the overall number of weed species. Dominant species include *Matricaria recutita, Polygonum aviculare* and *P. convolvulus*.

The number of farmland birds frequenting the crop edges was determined in a linear transect census (strip census; Hustings *et al.*, 1989), with all birds visiting a sprayed or unsprayed edge being recorded (ground contact). In 1993 a census was also made of the number of birds visiting an imaginary strip in the centre of each field and visiting the other side of the field. A census was additionally carried out of the number of birds sighted across the ditch on the adjacent field, where in most cases the crop was potatoes or sugar beet rather than winter wheat. All the strips recorded had the same area. In 1992 10 census sessions were performed on each farm between 08.30 h and 14.30 h in the period from 26 May to 7 July. In 1993 a weekly census was undertaken between 15 April and 15 July, with 5 sessions being held at each farm between 06.00 h and 09.00 h and 7 sessions between 09.00 h and 16.15 h Central European Time.

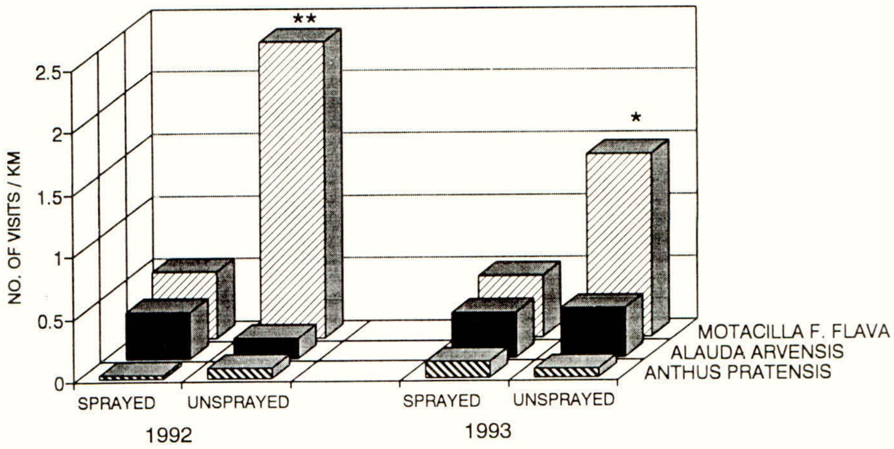
In 1993, at the same time as the strip census, for each species of bird the number of territories was determined in the entire winter wheat field as well as in the first 100 m of each adjacent field. The area recorded on each farm had an average size of 27.8 ± 6.9 ha. In preparing the territory maps, both territory-indicative and nest-indicative sightings were used (SOVON, 1985). A positive territory indication was recorded only for conclusive observations or concentrations of very widely distributed observations that fell within the valid date limits for the species in question. Finally, in 1993 a number of individuals of *Motacilla flava flava, Alauda arvensis* and *Anthus pratensis* was observed in order to study differences in feeding behaviour in sprayed and unsprayed crop edges. To this end, between 08.00 h and 14.45 h from 4 June to 16 July a total of 15 birds were observed for more than one hour on 6 farms from an observation post camouflages with a net. A record was made of the time spent by the birds on the following activities; flying, singing, feeding, resting and 'unseen field presence' (= bird present in the field but not visible).

RESULTS

Major differences were found in the presence of the three species on the crop edges. *Motacilla flava flava* was most frequently observed. In 1992 a total of 110 visits by this species to sprayed and unsprayed edges was recorded; in 1993 this figure was 60. *Alauda arvensis* was recorded 20 and 23 times in these two years, respectively, and *Anthus pratensis* only 4 and 6 times. In the two years of study the total number of visits by *Motacilla flava flava* (Figure 1) to the unsprayed crop edges was significantly higher than in the sprayed edges (significant difference $P = 0.007$ in 1992 and $P = 0.03$ in 1993; Wilcoxon paired sample test). The difference was greater by a factor of 3 to 4.5 in the unsprayed edges. In the two years the average number of visits by *Motacilla flava flava* per km crop edge was 2.37 and 1.46, respectively, in the unsprayed margins as compared with 0.53 and 0.49 in the sprayed margins. Throughout the census period of both years the number of visits by *Motacilla flava flava* was consistently higher in unsprayed edges, with the exception of one census session in 1993.

In the case of *Alauda arvensis* and *Anthus pratensis*, in neither year there was a significant difference in species abundance in sprayed and unsprayed edges. The greatest number of visits to crop edges was 0.39 per km for *Alauda arvensis* and 0.13 per km for *Anthus pratensis*. It is noteworthy that 3 of the 6 sightings of *Anthus pratensis* were during the first census session and that 4 birds were observed on just one farm.

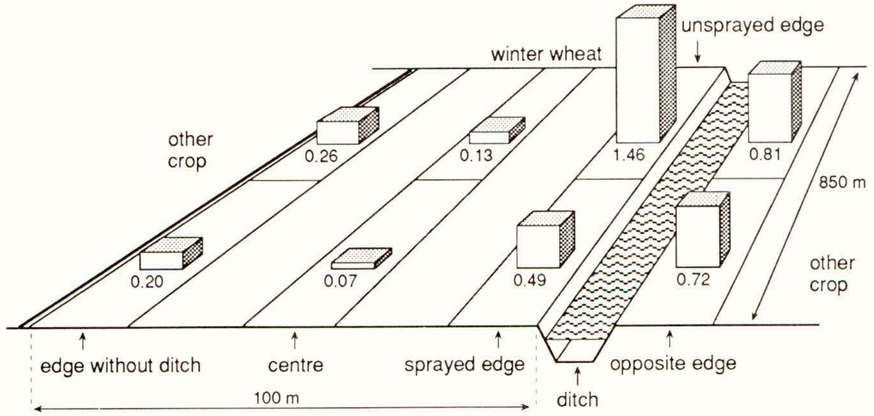
FIGURE 1. Number of visits by bird species per km in sprayed and unsprayed winter wheat edges in 1992 and 1993 (* = $P < 0.05$; ** = $P < 0.01$; Wilcoxon paired sample test)



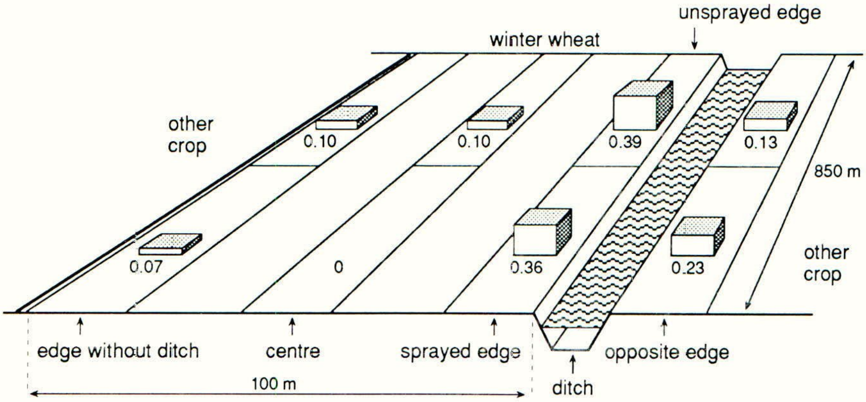
An analysis of species abundance over the entire plot indicated that the number of visits by *Motacilla flava flava* and *Alauda arvensis* to field edges was greater than that to the plot centre (Figure 2). This also seemed to be the case for *Anthus pratensis* but the number of observations was very small. The count was also higher for visits to sprayed edges bordering on a ditch than to sprayed edges directly adjacent to a second plot.

FIGURE 2. Total number of visits of bird species per km during the 1993 season in the various parts of the fields; 2A = *Motacilla flava flava*, 2B = *Alauda arvensis* and 2C = *Anthus pratensis*

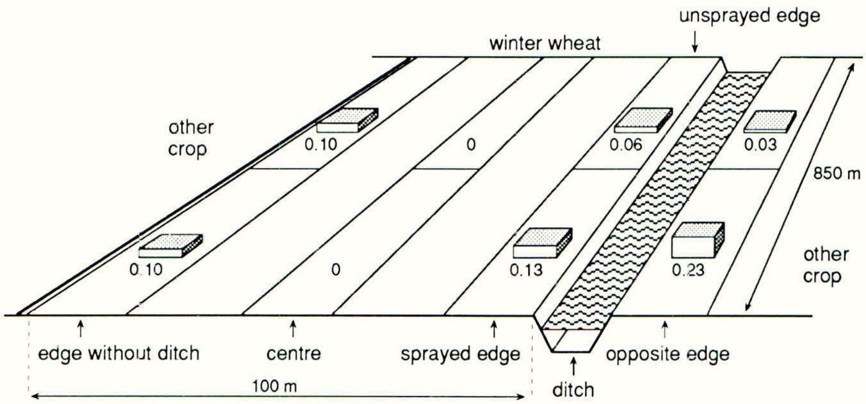
2A: *Motacilla flava flava*



2B: *Alauda arvensis*

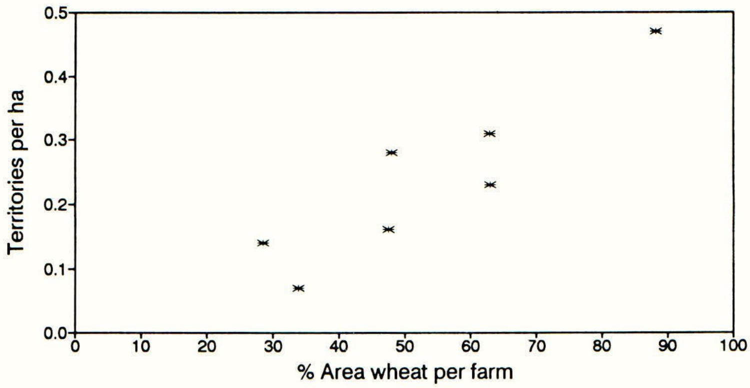


2C: *Anthus pratensis*



The exact shape and size of the territories could not be established, because there were too few boundary conflicts between birds. For each bird species, however, the total number of territories in the area investigated on each farm was determined and compared with the crop area on the respective farms. The territories of farmland birds generally encompass several plots, with different crops. A positive correlation was found between the number of territories of *Motacilla flava flava* per ha and the percentage wheat crop area per farm (Figure 3; linear regression coefficient r = 0.91). With the other two species, no relationship was found between the area of a given crop and the number of territories.

FIGURE 3. Number of territories of *Motacilla flava flava* in 1993 per ha compared to area of winter wheat (in %) in area studied on each farm



The results of the observations of individuals of *Motacilla flava flava* are shown in Table 1. For the larger part of the observation period this species had an 'unseen field presence', and consequently during this period no definite conclusions could be drawn as to activities. Feeding could be observed during a number of brief periods only. *Motacilla flava flava* was observed to feed both on the ground and on the crop itself. Because of the limited number of observations, no difference could be observed in the length of time spent feeding in sprayed versus unsprayed crop edges. Neither *Alauda arvensis* nor *Anthus pratensis* were observed to feed.

TABLE 1. Mean percentage of total time spent on each activity by *Motacilla flava flava*

Activity	Flying	Singing	Resting	Feeding	Unseen
% time	2.9 ± 1.3	4.7 ± 5.9	2.5 ± 4.2	1.2 ± 1.6	88.7 ± 8.1

DISCUSSION

Leaving a 6-metre wide strip along the edge of a crop unsprayed has pronounced positive effect on the number of visits by *Motacilla flava flava*. However, based on the small number of individual bird observations, it was not feasible to determine whether *Motacilla flava flava* indeed feeds more in unsprayed crop edges. Establishing unsprayed crop edges seemed to have no positive effect on the abundance of *Alauda arvensis*. A similar lack of effects of unsprayed crop edges on abundance of *Anthus pratensis* was indicated, but the number of observations of the latter species was extremely small. *Motacilla flava flava* is insectivorous, and insects such as Heteroptera, Chrysomelidae, Curculionidae and Carabidae are generally more abundant in unsprayed winter wheat edges (Rands, 1985; Storck-Weyhermüller & Welling, 1991 *etc.*). In our study area the most marked effects in the unsprayed edges were found on invertebrates which live on plants. The effects on soil invertebrates were only small (De Snoo, 1993; De Snoo *et al.*, 1994). The difference between *Motacilla flava flava* and *Alauda arvensis* may be explained since the latter species is partly herbivorous and a difference in feeding strategy: *Alauda arvensis* walks the ground feeding from the soil surface and the lower parts of plants, but never perches on plants to feed (Green, 1978, Cramp, 1988). However, *Motacilla flava flava* will also eat insects from te upper parts of the plants or even from the air (fly-catching) (Cramp, 1988). Moreover, *Alauda arvensis* may be avoiding the profuse weed growth in the unsprayed edges. The larger number of visits by all three species to the edges as compared with the centre of the plots may be due, on the one hand, to there naturally being more weeds and insects, i.e. a greater supply of food, along field edges (Hill, 1985) and, on the other, to the birds making use of the adjacent ditch and ditch banks.

The number of territories of *Motacilla flava flava* per hectare increases more than proportionally with the area of wheat per ha, a doubling of the percentage area of wheat giving 2.6 times more territories (Figure 4). The fact that this species benefits greatly from cultivation of this particular crop and, moreover, shows far greater abundance after establishing unsprayed crop edges makes it attractive to opt for this crop if the aim is to increase nature conservation of arable land. In addition leaving the winter wheat crop edge unsprayed is economically viable (De Snoo, these proc.).

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